

Did a Reaction Happen? Six Changes, One Decision Table

Investigation question: For six everyday changes, which clues only look like a reaction, which property tests settle the question, and how strong is the evidence for each decision?

Data-driven decision

Groups of 4

2 sessions

Setup 10 · Activity 80 · Cleanup 10 min

MS-PS1-2 · assesses

Scientific purpose

Students run six changes with household chemicals, record the clues each one shows (gas, temperature, color, solid, smell), save the products, and in a second session test the properties of what they saved: can the original substance be recovered, does the product dissolve, does it hold a magnet, does the leftover liquid still react. They then fill a decision table that separates clue from proof and rate the strength of their evidence. The lab is the chapter's assessment-level experience of analyzing properties before and after substances interact.

Why this helps students with this chapter

The chapter's hardest idea is that bubbles and heat are clues, not proof. Students only believe that after a hot cup turns out to be dissolving and a quiet cloudy cup turns out to be a reaction. Saving the products and coming back to test them a day later also mirrors what chemists actually do: the decision is made at the bench with property tests, not at the moment of the fizz.

Standards connections

MS-PS1-2 (assesses, analyzing before-and-after property observations to determine whether a chemical reaction occurred): The decision table requires a property comparison for every change (solubility of the product, recovery of the original substance, a chemical property of the leftover liquid, magnetism and texture of rust) and a reasoned reaction-or-not verdict with an evidence rating. Measured properties stay within the boundary (solubility, odor) or are observational comparisons; density and melting point data are supplied in W5 rather than measured here.

Roles (rotate each session)

- **Mixer:** Adds the solid or liquid for each change in the stated amount, stirs where the step says, and never adds anything that is not on the card.
- **Observer:** Reads the thermometer before and after, watches for gas, color, solid and smell (wafting only), and reports in plain words.
- **Recorder:** Fills the clue table in session 1 and the property-test and decision tables in session 2; checks that every cell has an entry.
- **Curator and safety captain:** Labels and stores every product cup and drying spot on the group tray, checks goggles before each change, and runs the cleanup list.

Materials

Item	Quantity	Per	Note
White vinegar	60 mL	group	
Baking soda	about 6 g (1 heaping teaspoon)	group	
Epsom salt	about 3 g (half a teaspoon)	group	
Calcium chloride pellets	about 1.5 g (a level quarter-teaspoon)	group	Label must say calcium chloride only. Crushed before class.
Baking soda solution (1 teaspoon per 100 mL water)	15 mL	group	Teacher-made; clear. 10 mL is used in change 4; keep the rest covered for the session-2 drop tests.
Calcium chloride solution (1 teaspoon per 100 mL water)	15 mL	group	Teacher-made the same day; it warms as it is made, let it cool to room temperature.
Fine (0000) steel wool	2 tufts the size of a walnut	group	One is reacted, one is kept as the 'before' sample.
Hydrogen peroxide, 3% (drugstore)	40 mL	group	
Active dry yeast	half a teaspoon	group	
Tap water at room temperature	100 mL	group	
Clear plastic cups (about 100 mL)	12	group	
Dark plastic lid or black plastic sheet for drying spots	1	group	White residues show up on a dark surface; a black plastic plate works.
Droppers or 1 mL syringes	4	group	
Digital thermometer	1	group	
Small magnet	1	group	
Hand lens	1	group	
Splash goggles	1 pair	student	
Tray, marker, paper towels, plastic spoons	1 set	group	

Estimated cost: 25 to 35 per class (an estimate; Estimate. Vinegar (\$3), baking soda (\$1), Epsom salt (\$5), calcium chloride (\$10 to \$15, shared with Lab 1), steel wool (\$4 for a pack), hydrogen peroxide (\$2 per bottle, two bottles), yeast (\$2), 100 cups (\$5). Thermometers, magnets and goggles assumed to be stock.)

Safety

- Splash goggles on for both sessions. Vinegar, hydrogen peroxide and calcium chloride solutions irritate eyes; rinse 15 minutes at the eyewash if splashed.
- Nothing is tasted. Smell only by wafting with a hand; never put your nose over a cup.
- Hydrogen peroxide 3% bleaches skin white briefly and stings cuts; wash off with water. Do not mix it with anything except what the card says, and never pour vinegar and peroxide together into a bottle or store them mixed: together they slowly form peracetic acid, a stronger irritant. In change 5 the peroxide goes onto a squeezed tuft in an open cup, and that liquid is poured away at the end of session 1.
- Steel wool fibers splinter into fingers; handle with the spoon or wear gloves. Steel wool can burn: keep it away from any heat source, batteries or sparks. No flames are used anywhere in this lab.
- Calcium chloride cups get warm; use the stated amount, do not touch the solution, and report any cup that feels hot.
- Never seal a cup or bag that is fizzing or foaming. Keep all cups uncovered.
- Cleanup: liquids down the sink with running water, including peroxide and yeast; steel wool and rust in the trash wrapped in a paper towel; wash hands.

Teacher preparation and setup

1. Make the two test solutions the same day: baking soda solution (1 teaspoon in 100 mL warm water, stir until clear) and calcium chloride solution (1 teaspoon in 100 mL water; it warms, so let it cool). Pour 15 mL of each per group into labeled cups.
2. Tear steel wool into walnut-sized tufts with gloves; the fibers splinter. Put two per group in a labeled bag.
3. Run change 5 (steel wool) and change 6 (yeast) yourself once so you know how fast they go and how warm they get with your peroxide; a fresh bottle works better than an old one.
4. Set up a drying shelf where each group's dark plastic lid with its labeled drops can sit undisturbed overnight; the residues are what session 2 tests.
5. Print the recording sheet; session 1 uses the clue table, session 2 uses the property-test and decision tables.

Investigation design

Independent variable	Which change is carried out (1 to 6)
Dependent variable	Clues observed during the change, and the properties of the saved products compared with the starting substances (solubility, recovery by drying, reaction with vinegar, magnetism, color and texture, reaction with fresh reactant)
Controlled	Stated amounts and volumes for every change; Same thermometer, same 60-second or stated wait before readings; Same water for every test in session 2; 'Before' samples of every starting substance tested with the same procedure as the products
Trials	One run of each change per group; six to eight groups give the class repeated trials, pooled on the board in session 2.

Comparison

Properties of each product against the properties of the substances that went into the change.

Student procedure

1. Session 1. Goggles on. Label six cups C1 to C6 and six product cups P1 to P6. Write your group name on the dark lid and mark six drying spots D1 to D6 on it.
2. Change 1: 20 mL vinegar in C1; read the temperature. Add a level quarter-teaspoon of baking soda. Record gas, temperature after 60 seconds, color, smell. When the fizzing stops, pour the liquid into P1 and put three drops on spot D1.
3. Change 2: 20 mL water in C2; read the temperature. Add half a teaspoon of Epsom salt and stir 30 seconds. Record what you see and the temperature. Pour into P2; three drops on D2.
4. Change 3: 20 mL water in C3; read the temperature. Add a level quarter-teaspoon of calcium chloride and stir 30 seconds. Record what you see and the temperature. Pour into P3; three drops on D3.
5. Change 4: 10 mL baking soda solution in C4; read the temperature. Add 10 mL calcium chloride solution and swirl once. Watch for two full minutes. Record gas, cloudiness, solid, temperature. Let the cup sit undisturbed; this is P4.
6. Change 5: Soak one tuft of steel wool in 10 mL vinegar in C5 for one minute, then lift it out with a spoon, squeeze it against the cup wall and move it to P5. Add 10 mL hydrogen peroxide to the tuft. Hold the thermometer against the tuft. Record color, temperature over three minutes, gas, smell. Keep the second, untouched tuft as the 'before' sample.
7. Change 6: 20 mL hydrogen peroxide in C6; read the temperature. Add a quarter-teaspoon of yeast and swirl once. Record foam, temperature after two minutes, smell. When the foam settles, pour the liquid into P6, leaving the yeast sludge in C6. Keep both.
8. Pour the liquid off P5 down the sink with running water, keeping the tuft. Put the dark lid on the drying shelf and the product cups on the tray with the 'before' steel wool, the remaining baking soda, Epsom salt and calcium chloride, and the leftover yeast. Clean up the C cups except C6.
9. Session 2. Goggles on. Drying spots first: look at D1, D2, D3 with the hand lens and describe each residue. Scrape a little of each residue into a cup with 5 mL water: does it dissolve? Add a drop of vinegar to another part of each residue: fizz or not? Put a drop of baking soda solution on a third part: does it turn cloudy white? Do the same three tests on small pinches of fresh baking soda, Epsom salt and calcium chloride as the 'before' samples and record all six side by side. (A few dried drops are far too little to change the temperature of water, so temperature is not one of these tests.)
10. P1 leftover test: add a pinch of baking soda to half of P1 (fizz means acid remained). Add five drops of vinegar to the other half (fizz means baking soda remained). Record which reactant was used up.
11. P4: pour off the clear liquid carefully. Add 10 mL water to the white solid and stir: does it dissolve? Compare with how both starting solutions were made (both solids dissolved). Add five drops of vinegar to the solid: fizz? Record.
12. P5: hold the magnet beside the untouched steel wool, then beside the orange product. Compare the pull, the color, the shine and how each breaks apart under the spoon. Put a pinch of each in 5 mL water: does either dissolve?

13. P6: add 10 mL fresh hydrogen peroxide to the yeast left in C6 and record. Add a quarter-teaspoon of fresh yeast to the liquid in P6 and record. Decide which substance was used up and which was not.
14. Fill the decision table: for each change, the clues seen, the property test you did, what differed (or did not) before and after, your verdict, and a strength rating with a reason. Answer the analysis questions on your own.

Expected observations

- Change 1: strong fizz, temperature drops a few degrees, no color change, vinegar smell; the dried residue (D1) is a white crystalline film that dissolves in water and does not fizz with vinegar, unlike baking soda. With a level quarter-teaspoon in 20 mL vinegar the acid is in slight excess, so the leftover liquid fizzes when baking soda is added and not when vinegar is added.
- Change 2: crystals dissolve, temperature drops 1 to 2 °C, no gas; D2 dries to white crystals that dissolve readily, do not fizz and stay clear (at most faintly hazy) with a drop of baking soda solution, the same as fresh Epsom salt.
- Change 3: pellets dissolve, temperature rises clearly (roughly 8 to 15 °C), no gas; D3 dries slowly, if at all, to a white, often damp residue that dissolves readily, does not fizz and turns a drop of baking soda solution cloudy white, the same as the pellets.
- Change 4: the mixture turns cloudy white within a minute and small bubbles rise slowly; little or no temperature change. The settled white solid does not dissolve in fresh water and fizzes with vinegar.
- Change 5: after the peroxide is added the tuft turns orange-brown within two or three minutes, warms by several degrees, and a few small bubbles appear; the product is dull, crumbly and barely attracted to the magnet, while the untouched tuft is shiny, springy and jumps to the magnet. Neither dissolves in water.
- Change 6: thick foam rises, the cup warms by a few degrees, faint bread smell; fresh peroxide on the used yeast foams again, fresh yeast in the used liquid does nothing.

Likely difficulties

- Residue D3 may still look wet the next day because calcium chloride pulls water from the air; that dampness is itself a property the pellets share, and the dissolving, vinegar and baking soda drop tests still work on a damp residue. Do not expect it to warm water: a few dried drops are too little, and calcium chloride that dried at room temperature holds water that stops it warming water as the pellets did.
- Groups skip the 'before' tests on fresh baking soda, Epsom salt and calcium chloride and then have nothing to compare the residues with; make the side-by-side a required row.
- Old hydrogen peroxide gives weak foam and slow rust; use a fresh bottle and keep the cap on between uses.
- The small bubbles in change 4 make students call it 'the same as change 1'; ask what else appeared (a solid) and which test told the solid apart from both starting substances (it does not dissolve).
- Students rate evidence by how dramatic the change was. The rubric asks them to rate by how many characteristic properties differed and whether the original could be recovered.

Structured debrief

1. Put the six verdicts on the board with the class vote from session 1 next to them. Expect change 3 (calcium chloride, hot) to have been called a reaction by most groups on day one and a physical change by most on day two. Ask which results flipped it: the dried residue dissolved readily, did not fizz and turned a drop of baking soda solution cloudy, the same behavior as the pellets.
2. Contrast change 3 with change 4 using the same chemical. Calcium chloride dissolving is physical; calcium chloride solution meeting baking soda solution is a reaction, because a solid appeared that does not dissolve although both starting solids do. Same substance, different partner, different verdict: a reaction needs the right substances together, not just an event.
3. Collect the 'same' results (rust and steel wool both insoluble; residue 2 looks like Epsom salt) and ask what each one means. A 'same' result for a product is evidence that no reaction happened only when it comes with recovery of all the original properties; a 'same' result on one property with other properties different is simply a test that did not discriminate.
4. Close on the yeast: students assume everything you add gets used. The leftover test shows the peroxide was consumed and the yeast was not, so the yeast is a helper (an enzyme in it speeds the breakdown), not a reactant. Name the products as water and oxygen gas and note that we did not test the gas because the usual test needs a flame.

Recording sheet: what students fill in

Lab 2 recording sheet: Did a reaction happen?

Session 1: fill the clue table as each change runs. Write 'none' where you saw nothing; a blank is not data.

Session 2: fill the property-test table, then the decision table.

Session 1: clues seen during each change

Change	Temperature before (°C)	Temperature after (°C)	Gas? (none/bubbles/foam)	Color or solid change?	Smell? (waft only)	First guess: reaction or physical?
1 Baking soda + vinegar						
2 Epsom salt + water						
3 Calcium chloride + water						
4 Baking soda solution + calcium chloride solution						
5 Steel wool + vinegar, then peroxide						
6 Hydrogen peroxide + yeast						

Session 2: properties before and after

Change	Property tested	Starting substance(s): result	Product: result	Same or different?
1	Residue dissolves in water? Fizzes with vinegar?			
1	Leftover liquid: fizz with baking soda? with vinegar?			
2	Residue: looks like? dissolves? fizz? clouds soda solution?			
3	Residue: looks like? dissolves? fizz? clouds soda solution?			
4	White solid dissolves in water? Fizzes with vinegar?			
5	Magnet pull? Color and shine? Crumbles? Dissolves?			
6	Fresh peroxide on used yeast? Fresh yeast in used liquid?			

Decision table

Change	Clues (session 1)	Property evidence (session 2)	Verdict: reaction or physical change	Evidence strength (strong/medium/weak) and why
1				
2				
3				
4				
5				
6				

- Which change fooled your first guess in session 1, and which session-2 result changed your mind?

Answer: Most groups: change 3 (calcium chloride + water) fooled them because it got hot; the session-2 result that changed their mind was that the dried residue behaved like the original pellets: it dissolved readily, did not fizz with vinegar and turned a drop of baking soda solution cloudy. Some groups: change 4, which looked like nothing much until the solid turned out not to dissolve.

Why: Any honest account of a revised guess with a specific session-2 result earns credit.

- Names a change and the first guess
- Names a specific property result that changed the verdict

Analysis questions: answer key

2. Changes 1 and 3 both changed temperature. Explain why you reached different verdicts for them, naming the property evidence for each.

Answer: Change 1 is a reaction: the dried residue dissolves but does not fizz with vinegar, unlike baking soda, so a substance with a different chemical property is present; and a gas appeared that was not in either reactant. Change 3 is a physical change: the dried residue dissolves readily, does not fizz and clouds baking soda solution, exactly as the pellets did, so the original substance was recovered. The temperature changes went in opposite directions but neither one decided anything; the property comparisons did.

Why: The core contrast of the lab: identical clue type (temperature change), opposite verdicts, decided by properties.

- States the two verdicts
- Gives the residue-does-not-fizz (or gas) evidence for change 1
- Gives the recovery evidence for change 3
- Says temperature change was not the deciding evidence

3. In change 4 nothing dramatic happened: no big fizz, no heat, just a cloudy cup. Explain why it still earned a 'reaction' verdict and why the solubility of the white solid is the key piece of evidence.

Answer: Both starting solutions were made by dissolving solids that dissolve well, and both were clear. A white solid that will not dissolve in fresh water cannot be either of those solids; it is a substance with a different solubility. A difference in a characteristic property between the starting substances and the product is the kind of evidence that confirms a reaction. The solid's fizz with vinegar is extra support (calcium chloride does not fizz), but on its own it would not separate it from baking soda, so solubility is the key.

Why: Solubility is on the assessment-boundary list; students should see that quiet reactions are still reactions and that one well-chosen property settles it.

- Notes both starting solids are soluble
- States the product does not dissolve
- Connects the solubility difference to a new substance
- Treats the fizz as supporting, not decisive

4. The magnet pulled hard on the untouched steel wool and barely on the orange product. Why does that count as evidence of a new substance, and why would 'it turned orange' alone have been weaker evidence?

Answer: Magnetism is a property of the substance: steel wool (mostly iron) is pulled strongly, and the orange product is pulled weakly or not at all, so the product is not the same substance as the iron. Combined with the change in color, shine and texture (crumbly instead of springy), several properties differ at once, which makes the evidence strong. 'It turned orange' alone is weaker because a color change can happen without a new substance (a wet surface, a coating, a reflection) and because color is shared by many substances; one clue is a reason to test, not a conclusion.

Why: Students should connect multiple differing properties to strength of evidence and recognize color as a weak single clue.

- Explains magnetism as a property comparison before and after
- Lists at least one other property that differed
- Explains why color alone is weak

5. In change 6, fresh peroxide foamed on the used yeast but fresh yeast did nothing in the used liquid. Which substance was the reactant that got used up, and what role did the yeast play? What does this tell you about the liquid left in the cup?

Answer: Hydrogen peroxide was the reactant that got used up: fresh yeast added to the used liquid did nothing, so there was no peroxide left to break down. The yeast was not used up: fresh peroxide poured onto the old yeast foamed again, so the yeast still had whatever it needed. The yeast is a helper that speeds the reaction without being consumed. The liquid left in the cup is therefore not hydrogen peroxide anymore; its chemical property (foaming with yeast) is gone, which is evidence that a different substance (mostly water) is what remains.

Why: The leftover test is a chemical-property comparison of the product liquid with the reactant liquid, and it also corrects the 'everything added is a reactant' idea. The word catalyst is not required.

- Identifies peroxide as the consumed reactant
- States the yeast was not consumed and speeds the reaction
- Concludes the leftover liquid lost the reactant's property

6. Neither the steel wool nor the rust dissolved in water. Does that result argue against a reaction? Explain what a 'same' result in a property test does and does not tell you.

Answer: No. A 'same' result means that particular test could not tell the two substances apart; it is not evidence that they are the same substance. Both iron and rust happen to be insoluble in water. The magnet, color and texture tests did differ, so the verdict stands. A 'same' result only argues against a reaction when every tested property matches and the original substance is recovered, as with the Epsom salt residue.

Why: Targets the counting-tests error; matching results are neutral unless they amount to full recovery.

- Says a same result is uninformative on its own
- Points to the properties that did differ
- Distinguishes this from the recovery case

7. Rank your six verdicts from strongest evidence to weakest. For the weakest, describe one more test (any property) that would strengthen it.

Answer: A defensible ranking: change 5 (rust) or change 1 strongest, with several properties differing (magnetism, color, texture; or residue chemistry plus a new gas); change 4 strong on solubility alone; change 6 medium, decided by the leftover test with no test of the gas; changes 2 and 3 are confident physical-change verdicts because the original was recovered. For the weakest reaction verdict (usually change 6), a further test would be collecting the gas and testing a property of it (the usual glowing-splint test needs a flame, so it could only be a teacher demonstration outside this chapter).

Why: Rankings vary; credit depends on ranking by number and kind of differing properties and on a sensible extra test.

- Ranks all six with reasons based on properties, not drama
- Proposes a property-based additional test for the weakest case

8. A friend who missed the lab says: 'Just tell me the rule: bubbles or heat means reaction.' Write the better rule in two sentences, using one example from this lab for each sentence.

Answer: Bubbles or heat are clues that something happened, but dissolving calcium chloride got hot and nothing new formed, so a clue is a reason to test, not a verdict. A change is a reaction when a property comparison shows a substance that was not there before, as when the cloudy solid in change 4 would not dissolve although both starting solids do.

Why: Two sentences, two examples, clue-versus-proof made explicit.

- First sentence: clue is not proof, with a physical-change example
- Second sentence: property comparison decides, with a reaction example

Individual evidence of learning

Each student submits their own three tables and written answers to q1 through q8. The decision table with its strength ratings and q2, q3 and q7 are the primary evidence toward MS-PS1-2; q5 and q6 show whether the student can interpret leftover and 'same' results.

Assessment criteria

Criterion	Proficient looks like
Observations	Every clue-table cell filled with a specific observation and temperatures with units; 'before' and product results recorded side by side for every property test.
Verdicts	Changes 1, 4, 5 and 6 judged reactions and 2 and 3 judged physical changes, each tied to a named property comparison rather than to a clue.
Evidence strength	Ratings justified by the number and kind of properties that differed and by recovery results, not by how dramatic the change looked; a further test proposed for the weakest case.
Interpreting null and leftover results	Explains that a 'same' result is uninformative on its own, and reads the leftover tests correctly (acid remained in change 1; peroxide, not yeast, was consumed in change 6).

Accessibility adaptations

- Pre-measure every solid into labeled cups so the Mixer only pours; provide a large-print card for each change with one step per line.
- Temperature, foam and the magnet's pull are all non-visual evidence; let students with low vision run those tests and describe them, with a partner describing color.
- Allow the decision table to be completed as a sorted card set (clue cards, test cards, verdict cards) for students who need movement or who write slowly, photographed as the record.
- Offer a sentence frame for verdicts: 'Before, ___ was ___. After, ___ was ___. These are (the same / different), so this was a ___ change.' Accept spoken answers for q7 and q8 recorded on a device.

Low-cost alternative

Run changes 1, 3, 4 and 5 only, which still include two reactions with different clue patterns and the hot dissolving trap; share one thermometer and magnet between two groups; dry the drops on the back of a

plastic plate from the cafeteria.

Model limitations

Kitchen chemicals limit which properties can be measured: melting points and densities of these products are not practical here, so solubility, recovery and a chemical property (reaction with vinegar or with fresh reactant) carry the decisions, and the magnet test is an extra property outside the standard's list.

Temperature is not used in the recovery tests, because dried drops are too small to change it. The yeast gas is not tested because the test needs a flame. The lab has not been physically tested by the authors; timings and temperature changes are estimates and should be checked with your materials before class.

Teacher notes

The decision table is the main artifact; check that every 'reaction' verdict names a property that differed and every 'physical' verdict names a recovery result. Expect strength ratings to differ between groups and discuss the differences rather than correcting to one answer. If a group's change 1 leftover liquid fizzed with vinegar and not with baking soda, their quarter-teaspoon was heaped or their vinegar was weaker than 5%, and baking soda was in excess; the verdict is unaffected, and it is a good link to Lab 3.